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(54) Title of the invention Method of cutting reinforced concrete structure

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SPECIFICATION

1. TITLE OF THE INVENTION

Method of cutting reinforced concrete structure

2. WHAT IS CLAIMED IS :

(1) Method of cutting a reinforced concrete structure in which a reinforced concrete structure which is to be cut is melted by a laser light beam and, immediately after this, a bullet for explosion which is formed to a grain shape is driven into a melt crater in said structure and said bullet is caused to explode by laser light beam energy, thereby causing local fragmentation of a small portion of said structure.

(2} Method as claimed in Claim 1, wherein said bullet is formed as a solid of a curved surface of revolution with a diameter smaller than a melt crater which is formed in said reinforced concrete structure which is to be cut by a laser light beam.

(3) Method as claimed in Claim 1, wherein said bullet is formed by layer adhesion on the outer periphery of an explosive or admixture with said explosive of a bursting element which is constituted by material with great specific gravity and strength and is for the purpose of increasing the post-explosion break-up force.

(4) Method as claimed in Claim 1, wherein the surface of said bullet is surface-treated in order to impart suitable laser light beam absorption efficiency.

3. DETAILED DESCRIPTION OF THE INVENTION

Field of industrial use

The present invention relates to a method of cutting a reinforced concrete structure.

Prior art

Conventionally, a method of effecting fragmentation by means of gunpowder is practised as a method of cutting structures.

Also, a method of melt-cutting by means of a laser light beam has been proposed recently.

Problems intended to be resolved by the invention

However, with the method of fragmentation by gunpowder, although the method is effective in the case of structures which are not reinforced by reinforcement rods, it is not possible to hope for accurate fragmentation, and, rather than effecting cutting, this method effects total fragmentation, with considerable production of powder and dust and of vibration and noise.

Also, in the case of a reinforced concrete structure, the reinforcement rods cannot be cut and therefore have to be cut by another method, so resulting in a large and complex system.

In the case of melt-cutting by means of a laser light beam, the melt-cutting becomes difficult, since the laser light beam causes a highly viscous melt to be produced in a cutting groove in the structure.

Means for resolving the problems

The present invention is one which has been devised for the purpose of resolving such problems, and it relates to a method of cutting a reinforced concrete structure in which a reinforced concrete structure which is to be cut is melted by a laser light beam and, immediately after this, a bullet for explosion which is formed to a grain shape is driven into a melt crater in the structure and this bullet is caused to explode by laser light beam energy, thereby causing local fragmentation of a small portion of the structure.

Effect

In the invention, since, as described above, a bullet which is formed to a grain shape is driven in immediately after a reinforced

concrete structure has been melted by a laser light beam, oscillation of the laser light beam causes the bullet to pass via a cutting groove which has been formed in the structure and to collide with and disperse a highly viscous melt which has been produced in the bottom portion of this groove, and, as the result of the exchange of energy between the bullet and the dispersed melt, the bullet comes to a halt in the melt crater.

At the same time, since the bullet is irradiated by the laser light beam, it absorbs energy of the laser light beam and explodes, and the portion lying along the cutting groove in the structure is broken up.

In this manner, a new exposed surface is produced in the structure's cutting groove and, since this surface is subjected to laser light beam irradiation, a melt is produced again.

Cutting of the structure is effected by subsequent repetition of the above cycle.

<u>Advantage of the invention</u>

Thus, according to the invention, a reinforced concrete structure is melted by a laser light beam, a bullet which is formed to a grain shape is driven into the resulting melt crater, so effecting cutting of the structure and removal of cut-off material, and, by making use of local break-up in which the powerful destructive force of gunpowder is accurately controlled, the invention improves the efficiency and precision of cutting of the structure.

<u>Example of practice</u>

An example of practice will now be described with reference to the drawings.

Fig. 5 shows a reinforced concrete structure cutting apparatus which is used in the method of the invention. 1 is a laser light beam oscillation head, and the arrangement is made such that melt-cutting of a reinforced concrete structure C is effected by a laser light beam L which is generated by this head 1.

2 is a gun barrel for firing bullets which are projected into a melt-cutting groove which is formed in the reinforced concrete structure C by the laser light beam L. A pair of infrared detectors 3 are provided at the front end of and on opposite sides of this gun barrel 2.

An infrared detector 3 is constituted by the provision of lens structures respectively at the front and rear of a cylinder body and the provision of an infrared sensor to which a signal transmission cord is connected, and it is made such that it detects those infrared rays which are to be detected within the infrared rays emitted by a highly viscous melt W that is produced in the reinforced concrete structure C by the laser light beam L. Infrared rays which pass through the lens structures are detected by the infrared detection sensors and are sent via the signal transmission cords to a microcomputer (not shown), and the directions in which the infrared detectors are directed relative to the melt W are judged from the positional relations of the pair of infrared sensors on the left and right. Further, since the two detectors 3 are fixed with the gun barrel 2 in the centre, as noted above, and the axis of the gun barrel 2 is aimed at the melt W, the axis of the gun barrel 2 is aligned with the position of the melt W by a gun barrel direction control mechanism (not shown) which receives signals from the pair of infrared detection sensors on the left and right.

Since the position of the melt W constantly changes, it is necessary to constantly adjust the relation between the laser light beam L and the gun barrel 2.

4 is a bullet tank, 5 is a bullet supply pipe which connects this tank 4 and a bullet feed control unit 6, and a vibrator 7 is provided at a lower-end funnel-shaped portion of the tank 4 in order to cause bullets that are in the tank to be supplied in a sure manner under their own weight into the pipe 5. Since the tank 4 is a gravity supply unit, it is always held vertical by a universal joint (not shown), etc. Further, since the laser light beam L is directed to a variety of directions, the bullet supply pipe 5 is constituted by a flexible pipe.

In the bullet feed unit 6, a rotary cylinder which is in and is coaxial with a main body which has a circular cross section and whose front and rear communicate with the gun barrel 2 and the bullet supply pipe 5 is mounted on the rotation shaft of stepping motor 8, plural partition pieces are provided radially projecting at equal intervals in the rotary cylinder, so effecting division into bullet accommodation spaces between neighbouring partition pieces, through-holes are pierced in the rotary cylinder inner walls in each of these spaces, and a compressed air injection nozzle which faces the through-holes of the rotary cylinder is disposed on an extension of the central axis of the gun barrel 2.

Further, compressed air from an air compressor (not shown) is continuously supplied via an air hose 9 and from a nozzle 10 into the gun barrel 2.

It is noted that the abovedescribed reinforced concrete structure cutting apparatus is essentially the same as the cutting apparatus described in the present Applicant's Patent Application of the same date (Title of the invention : Structure cutting method and apparatus) but bullets are used instead of the spheres that are used in this apparatus.

Fig. 6 - Fig. 13 show examples of bullets B. These can be formed in a variety of shapes, such as the cocoon shape shown in Figs. 6 and 7, the shell shape shown in Figs. 8 and 9, the cylinder shape shown in Figs. 10 and 11 or the spheres shown in Figs. 12 and 13 and, in order to make effective use of the explosive force of gunpowder, bursting elements 12 of iron powder, etc. whose specific gravity and strength are great is adhered in layer form around an explosive 11 (see Figs. 6, 8, 10 and 12), or the bullet is formed as a mixture 13 of an explosive and a bursting element (see Figs. 7, 9, 11 and 13).

Also, in order to make effective use of the energy and wavelength of a laser light beam L, the outer surfaces of bullets B are surface-treated with high-absorptivity material such as titanium, silicon or graphite, etc.

Since the example shown in the drawings is constituted in the manner described above, a laser light beam L from the laser light

beam oscillation head 1 is generated and effects melt-cutting of the reinforced concrete structure C, and, in this process, infrared rays emitted by the melt W that is formed in the structure C are detected by the abovenoted infrared detectors 3, and the detection signals of these detectors are used by the gun barrel direction control mechanism to keep the axis of the gun barrel 2 constantly aligned with the melt.

Meanwhile, bullets B are supplied from the bullet tank 4 via the bullet supply pipe 5 into the bullet feed control unit 6, and 1 bullet enters a space that is formed between neighbouring partition pieces in the rotary cylinder.

Further, the rotary cylinder in the bullet feed control unit 6 is rotated in a set direction by the stepping motor 8, and, when the abovenoted space comes into correspondence with the gun barrel 2 and the supply pipe 5, the rotary cylinder is momentarily stopped, compressed air is injected from the through-hole at the rear of the space, via the nozzle provided at the rear, and the bullet B is discharged into the gun barrel 2 by the pressure of this compressed air. Further, since an empty bullet accommodation space is now positioned at the pipe 5 end, 1 bullet B is caused to roll into the empty space by gravity and by the vibration of the vibrator 7.

Compressed air injected from the nozzle 10 causes the bullet B which has been supplied into the gun barrel 2 in the manner described above to be fired from the gun barrel 2 and into a melt-cutting groove which has been formed in the structure C by the laser light beam L.

Thus, as illustrated in Fig. 1, the bullet B, which passes through the reinforced concrete structure C melt-cutting groove D produced by the laser light beam L, collides with the melt W that has been produced in the melt-cutting groove D, this melt W becomes a dispersed melt W', and, as the result of exchange of energy between the bullet B this dispersed melt W', the bullet B remains in a melt crater at the bottom of the melt-cutting groove D, as indicated in Fig. 2.

L' in Fig. 1 indicates the laser light beam of the preceding time.

At the same time, since the bullet B is irradiated by the laser light beam L, it absorbs energy of the laser light beam L and explodes, and, as indicated in Fig. 3, the weak direction which has been opened along the melt-cutting groove D in the structure C is broken up, becomes fragments F and is scattered. Thus, a new exposed surface N appears in the cutting groove D of the structure C, and a melt W is produced again, since this new surface N is subjected to laser light beam irradiation. Subsequently, the same cycle is repeated.

The depth of the melt W is detected with good precision by the infrared detectors 3 and, when a set cutting depth is reached, a move to the next cutting line is made and the operation described above is repeated, thereby effecting cutting of the structure C.

The distance S from the laser light beam L' which was radiated the preceding time to the newly radiated laser light beam L is made a dimension with which there is very suitable break-up and scattering of the structure C.

Thus, with the method of this example of practice, cutting of a reinforced concrete structure C and removal of cut-off material are effected as the result of the structure C being melted by a laser light beam L, and of a bullet B being driven into the resulting melt crater E and being exploded by the laser light beam L, and the structure C is cut up effectively and with good precision by making use of local break-up in which the powerful break-up force of gunpowder is accurately controlled,.

Gases and dispersed melt which are produced as the result of cutting by the laser light beam L and bullet B go via a waste recovery hose 14 connected to a suction processing unit (not shown) and are captured by being drawn into a recovery hood 15 which is provided at the front end of the laser light beam oscillation head 1.

Needless to say, although a description of the invention has been given above with reference to an example of practice, the invention is not limited solely to such an example of practice but a

variety of design modifications can be implemented within a range in which there is no departure from the spirit of the invention.

4. BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 - Fig. 3 are cross-sectional views showing stages in one example of practice of the reinforced concrete structure cutting method of the invention, Fig. 4 is a view along the line IV-IV of Fig. 1, Fig. 5 is a side view in longitudinal section which shows a reinforced concrete structure cutting apparatus which is used in the method of the invention, and Fig. 6 - Fig. 13 are side views in longitudinal section which show various examples of bullets.

B ... bullet
C ... reinforced concrete structure
D ... cutting groove
E ... melt crater
L ... laser light beam
W ... melt

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⑤発明の名称　鉄筋コンクリート構造物の切断方法

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明細書

1.〔発明の名称〕

鉄筋コンクリート構造物の切断方法

2.〔特許請求の範囲〕

(1) レーザー光線によつて被切断鉄筋コンクリート構造物を溶融した直後に、同構造物における溶融壷に粒状に成形された爆発用弾丸をたたき込み、同弾丸をレーザー光線のエネルギーによつて爆発させて前記構造物の小部分の局所破砕をすることを特徴とする鉄筋コンクリート構造物の切断方法。

(2) 前記弾丸はレーザー光線によつて被切断鉄筋コンクリート構造物に形成された溶融壷より小径の回転曲面体に成形された特許請求の範囲第1項に所載の方法。

(3) 前記弾丸は爆発後の破壊力を増大させるための比重、強度の大きい材料よりなる炸裂片を爆薬の外周に層着するか、同爆薬と混合して成形された特許請求の範囲第1項に所載の方法。

(4) 前記弾丸の表面はレーザー光線の適当な吸収効率を有するように表面処理された特許請求の範囲第1項に所載の方法。

3.〔発明の詳細な説明〕

（産業上の利用分野）

本発明は鉄筋コンクリート構造物の切断方法に係るものである。

（従来の技術）

構造物の切断方法として、従来火薬による破砕方法が行なわれている。

また最近レーザー光線による溶融切断方法も提案されている。

（発明が解決しようとする問題点）

しかしながら火薬による破砕方法は、鉄筋による補強のない構造物の場合には有効であるが、正確な破砕は期待できない。またこの方法は切断というよりは全体的な破砕となり、粉塵、振動、騒音の発生が大きい。

更に鉄筋コンクリート構造物の場合、鉄筋は切断できないので別の方法で切断しなければならず複雑且つ大規模な切断方法となる。

またレーザー光線による溶融切断の場合、構造物の切断溝内にレーザー光線による粘性の高い溶融物が生起するので、溶融切断が困難になる。

（問題点を解決するための手段）

本発明はこのような問題点を解決するために提案されたものであつて、レーザー光線によつて被切断鉄筋コンクリート構造物を溶融した直後に、同構造物における溶融壁に粒状に成形された爆発用弾丸をたたき込み、同弾丸をレーザー光線のエネルギーによつて爆発させて前記構造物の小部分の局所破砕をすることを特徴とする鉄筋コンクリート構造物の切断方法に係るものである。

（作用）

本発明においては前記したように、レーザー光線の照射によつて鉄筋コンクリート構造物を溶融した直後に、粒状に成形された弾丸をたたき込むようにしたので、同弾丸はレーザー光線の発振によつて前記構造物に形成された切断溝を通り、同溝底部に生起した粘性の高い溶融物に激突し、同溶融物を飛散せしめ、この弾丸と飛散溶融物とのエネルギー交換によつて弾丸は溶融壁に停止する。

これと同時にレーザー光線が弾丸を照射するので、同弾丸はレーザー光線のエネルギーを吸収して爆発し、前記構造物における切断溝に沿つた部分が破壊される。

かくして前記構造物の切断溝には新らしい露出面が生じ、同面にレーザー光線の照射を受けるので再び溶融物が発生する。

以下前記のサイクルが反覆されて前記構造物が切断される。

（発明の効果）

このように本発明によれば、レーザー光線によつて鉄筋コンクリート構造物を溶融してその溶融壁に粒状に成形された弾丸を打込み、同弾丸をレーザー光線で爆発させ、前記構造物の切断及び切断溝の除去を行ない、火薬の強力な破壊力を正確に制御した局所破壊を利用して前記構造物の切断効率及び精度を向上するものである。

（実施例）

以下本発明を図示の実施例について説明する。

第5図に本発明の方法に使用される鉄筋コンクリート構造物の切断装置を示し、(1)はレーザー光線発振ヘッドで、同ヘッド(1)より発振されたレーザー光線(L)によつて鉄筋コンクリート構造体(C)を溶融切断するようになつている。

(2)は前記レーザー光線(L)によつて構造物(C)に形成された溶融切断溝に投射される弾丸発射用砲身で、同砲身(2)の先端にこれを挟んで一双の赤外線検知器(3)が配設されている。

前記検知器(3)は筒体の前後に夫々レンズ機構及び信号伝達コードが接続された赤外線センサを装着して構成され、前記レーザー光線(L)によつて構造物(C)に発生した粘性の高い溶融物(W)より発生する赤外線のうち、検知すべき赤外線を検知するようになつている。そして前記レンズ機構を通過した赤外線を赤外線センサによつて検知して、これを信号伝達コードを介してマイクロコンピュータ（図示せず）に送り、左右一双の赤外線検知センサの位置関係より、赤外線検知器(3)が溶融物(W)に対してどの方向に指向しているかを判断する。而して前記したように、両検知器(3)は砲身(2)を中央に固定して溶融物(W)に砲身(2)の軸を合わせるようにしてあるので、左右一対の赤外線検知センサからの信号を受けた砲身の方向制御機構（図示せず）によつて砲身(2)の軸を溶融物(W)の位置に合わせる。

なお溶融物(W)の位置は常に変化するので、レーザー光線(L)と砲身(2)との関係は常に修正しなければならない。

(4)は弾丸タンク、(5)は同タンク(4)と弾丸送り制御装置(6)とを接続する弾丸給パイプで、弾丸タンク(4)内の弾丸が自重で前記パイプ(5)に確実に供送されるように、前記タンク(4)の下端漏斗状部に振動機(7)が附設されている。前記タンク(4)は重力による供給装置であるために、ユニバーサルジョイント（図示せず）等によつて常に鉛直に保持されている。またレーザー光線発振ヘッド(1)は種々の方向を向くので、弾丸供給パイプ(5)は可撓性パイプより構成される。

弾丸送り制御装置(6)は前後に砲身(2)及び弾丸供給パイプ(5)が逆通する円形断面の本体内に、これ

このように実施例の方法によれば、レーザー光線(L)によつて鉄筋コンクリート構造物(C)を溶融して、その溶融壺(E)に前記弾丸(B)を打込み、同弾丸(B)をレーザー光線(L)で爆発させることによつて、前記構造物(C)の切断及び切断屑の除去を行ない、火薬の強力な破壊力を正確に制御した局部破壊を利用し、前記構造物(C)を精度よく、効果的に破壊する。

なおレーザー光線(L)及び弾丸(B)による切断によつて生じた気体、飛散溶融体等は吸入処理装置（図示せず）に接続された廃棄物回収ホース(14)を介して、レーザー光線発振ヘッド(1)の先端に装着された回収フード(15)により吸入、捕捉する。

以上本発明を実施例について説明したが、本発明は勿論このような実施例にだけ局限されるものでなく、本発明の精神を逸脱しない範囲内で種々の設計の改変を施しうるものである。

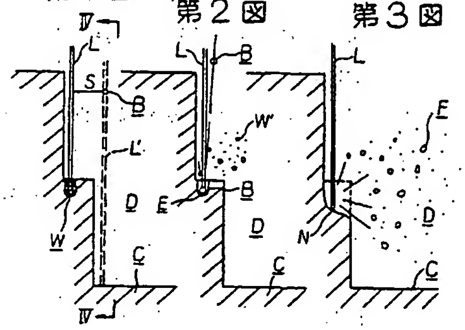
4.〔図面の簡単な説明〕

第1図乃至第3図は本発明に係る鉄筋コンクリート構造物の切断方法の一実施例の工程を示す縦断面図、第4図は第1図の矢視Ⅳ－Ⅳ図、第5図は本発明の方法に使用される鉄筋コンクリート構造物の切断装置の縦断側面図、第6図乃至第13図は夫々弾丸の各実施例を示す縦断側面図、第12図は第6図の矢視Ⅻ－Ⅻ図、第13図は第7図の矢視ⅩⅢ－ⅩⅢ図である。

(B)…弾丸、　(C)…鉄筋コンクリート構造物、
(D)…切断溝、　(E)…溶融壺、　(L)…レーザー光線、
(W)…溶融物

代理人　弁理士　岡　本　重　文
外2名

第1図　第2図　第3図



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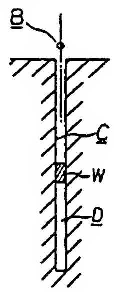

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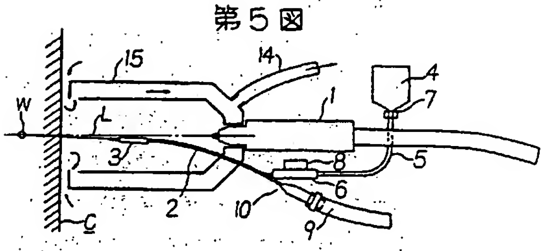
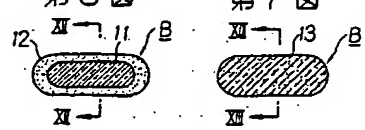
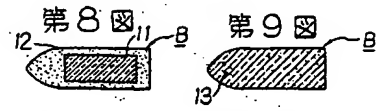


第6図　第7図



第8図　第9図



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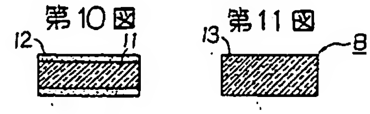
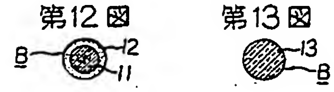


第12図　第13図



と同心状に回転筒がステッピングモータ(8)の回転軸に取付けられ、前記回転筒には等間隔毎に複数の仕切片放射状に突設され、相隣る仕切片の間に弾丸収容空間が仕切られ、同各空間における回転筒内壁面に透孔が穿設され、更に砲身(2)の中心軸の延長上において、回転筒の前記透孔に対向する圧縮空気噴射ノズルが配設されている。

更に前記砲身(2)にはエヤコンプレッサ（図示せず）からの圧縮空気がエヤホース(9)を介してノズル(10)より連続的に供給されるようになつている。

なお前記鉄筋コンクリート構造物切断装置は、本出願人の同日特許出願（発明の名称：構造物の切断方法及び装置）に示された切断装置と実質的に同一で、同装置に使用された球体の代りに弾丸が使用されるようになつている。

第６図乃至第１３図は弾丸(B)の実施例を示し、第６図及び第７図に示す繭形、第８図及び第９図に示す砲弾形、第１０図及び第１１図に示す円筒形、第１２図及び第１３図に示す球体等、種々の形状に成形され、爆薬の爆発力を有効に使用するために爆薬(11)の周囲に鉄粉等の如き比重及び強度の大きい炸裂片(12)を接着剤等で層着するか、（第６図，第８図，第１０図及び第１２図参照）、爆薬及び炸裂片の混合体(13)として成形される。（第７図，第９図，第１１図及び第１３図参照）

また前記弾丸(B)の表面は、レーザー光線(L)のエネルギー及び波長を有効に利用するためにチタン，シリコン，グラファイト等の吸収率の高い材料で表面処理される。

図示の実施例は前記したように構成されているので、レーザー光線発振ヘッド(1)からレーザー光線(L)を発振して鉄筋コンクリート構造物(C)を溶融切断するものであり、この際、同構造体(C)に形成された溶融物(W)より発生する赤外線を前記両赤外線検知器(3)で検知し、この検知信号により砲身の方向制御機構によつて砲身(2)の軸を常に前記溶融物(W)に合わせる。

一方、前記弾丸タンク(4)より弾丸(B)が弾丸送り制御装置(6)内に弾丸供給パイプ(5)を介して供給され、回転筒における相隣る仕切片の間に形成された空間に１個宛入る。

一方、前記弾丸送り制御装置(6)における回転筒はステッピングモータ(8)によつて所定方向に回転し、前記空間が砲身(2)及び前記供給パイプ(5)に合致したときに回転筒が瞬間的に停止し、前記空間背部の透孔からその背部に配設されたノズルを介して圧縮空気が噴射され、同圧縮空気の圧力で弾丸(B)は砲身(2)に放出される。一方、前記パイプ(5)側には空の弾丸収容空間が位置するので、弾丸(B)は重力と振動機(7)の振動によつて空になつた前記空間に１個宛転がり込む。

前記したように砲身(2)に供給された弾丸(B)はノズル(10)より噴射された圧縮空気によつて、砲身(2)より構造物(C)におけるレーザー光線(L)による溶融切断溝に発射される。

かくして第１図に示すように、レーザー光線(L)による鉄筋コンクリート構造物(C)の溶融切断溝(D)を通過する弾丸(B)が同切断溝(D)内に生起した溶融物(W)に激突し、同溶融物(W)は飛散溶融物(W′)となり、同飛散溶融物(W′)と弾丸(B)とのエネルギー交換により、弾丸(B)は第２図に示すように前記切断溝(D)底部の溶融壁(E)に停る。

なお第１図において(L′)は前回に照射されたレーザー光線を示す。

同時にレーザー光線(L)が弾丸(B)に照射するので、弾丸(B)はそのエネルギーを吸収して爆発して第３図に示すように、構造物(C)における切断溝(D)に沿つて開放された弱い方向が破壊され、破砕片(F)となつて飛散する。かくして前記構造物(C)の切断溝(D)には新らたな露出面(N)が表れ、同面(N)がレーザー光線(L)の照射を受けるので再び溶融物(W)が発生し、以下前記同様のサイクルが反復される。

なお前記赤外線検知器(3)によつて溶融物(W)の深さを精度よく検出して、所定切断深さに達したら次の切断ラインに移行して前記同様の操作を繰返し、前記構造物(C)を切断する。

なお前回照射されたレーザー光線(L′)から新らたに照射されるレーザー光線(L)までの距離Ｓは構造物(C)が丁度よく破砕され飛散する寸法を設定する。